

## PATENT ABSTRACTS OF JAPAN

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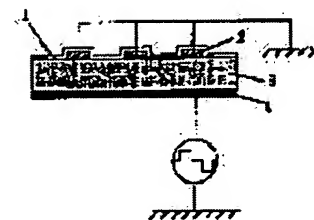
SHIMOKATA MIKIO

## (54) FERROELECTRICS ELECTRON EMITTING COLD CATHODE

## (57)Abstract:

PURPOSE: To enlarge the area of emission of electrons, and also, facilitate the supply to the whole of emission face of electrons for emission so as to stabilize and increase the amount of emission, by forming electron emission and supply electrode with a specified thickness to cover an upper electrode and ferroelectrics.

CONSTITUTION: An electron emission and supply electrode is made, thinner than an upper electrode and at a thickness of 5000 $\text{\AA}$ ; or under, in the specified area as occasion demands, such that it covers the the upper electrode 2 and the ferroelectrics 3, out of general electrode material such as Pt or the like. The upper electrode 2 is made in specified area and is grounded, and the ferroelectrics 3 are made in thickness of 100nm-2000 $\mu\text{m}$  out of PZT ceramics or the like. An either positive or negative specified electric field is impressed, for positive and negative regions, to the lower electrode 4 by a pulse generator 4. Hereby, the stable emission of a large quantity of electrons becomes possible.



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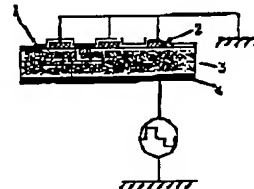
大阪府城東区豊野西6丁目12番6-307

(54) 発明の名称 強誘電体電子放出冷陰極

(57) 【要約】

【目的】電子の放出量を増加させ、しかも放出を安定させた強誘電体電子放出冷陰極。

【構成】強誘電体と、その強誘電体の電子放出面側に形成された上部電極と、その強誘電体の電子放出面側と反対の面に形成された下部電極とからなる強誘電体電子放出冷陰極において、前記上部電極および強誘電体の電子放出面を覆い、且つ厚さが上部電極よりも薄い電子放出および供給電極を強誘電体に形成することを特徴とする強誘電体電子放出冷陰極。



1...電子放出および供給電極  
2...強誘電体  
3...上部電極  
4...下部電極

## 【特許請求の範囲】

【請求項1】 強誘電体と、その強誘電体の電子放出面側に形成された上部電極と、その強誘電体の電子放出面側と反対の面に形成された下部電極とからなる強誘電体電子放出冷陰極において、前記上部電極および強誘電体の電子放出面を覆い、且つ厚さが上部電極よりも薄い電子放出および供給電極を強誘電体に形成することを特徴とする強誘電体電子放出冷陰極。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】 本発明は、電子源として利用する強誘電体電子放出冷陰極に関するものである。

## 【0002】

【従来の技術】 図2は強誘電体を利用した強誘電体電子放出冷陰極であり、H. Gundel等によって報告されたものである（Journal of Applied Physics p975 69 (2) (1991)）。Aは第一の電極、Bは強誘電体、Cは第二の電極である。また、図2は特開平5-925777で記載された強誘電体電子放出冷陰極であり、Aは第一の電極、Bは強誘電体、Cは第二の電極、Dは絶縁膜、Eは第二の電極である。図1および図2のように構成された従来の強誘電体電子放出冷陰極において、第一の電極と第二の電極の間に交番電界を印加すると、その電界の変化に伴い強誘電体内部の分極が変化（分極反転）を起こし、その際に第二の電極近傍に存在する電子をクーロン力により弾き飛ばし、電子の放出を行うものである。

## 【0003】

【発明が解決しようとする課題】 しかしながら上記のような構成では、第二の電極近傍に存在する電子しか放出に利用されない、言い換えれば電子の放出面積が限定されてしまうため、電子の放出量は少なく、実用的な電子放出源としては使用できないという問題があった。また、電子放出量を増加させるためには、第二の電極を多数あるいは微細に加工し、電子の放出面積を広げなければならないが、その作製工程は極めて困難であるという問題があった。

【0004】 本発明は、このような実情を鑑みなされたもので、実用的な強誘電体電子放出冷陰極を提供することを目的とする。

## 【0005】

【問題点を解決するための手段】 上記問題点は、強誘電体とその強誘電体の電子放出面側に形成された上部電極と、その強誘電体の電子放出面側と反対の面に形成された下部電極とからなる強誘電体電子放出冷陰極において、前記上部電極および強誘電体の電子放出面を覆い、且つ厚さが上部電極よりも薄い電子放出および供給電極を強誘電体に形成することを特徴とする強誘電体電子放出冷陰極によって解決される。

【0006】 本発明における強誘電体はPZT (Pb

(Zr, Ti)O<sub>3</sub>], PLZT [(Pb, La) (Zr, Ti)O<sub>3</sub>], BaTiO<sub>3</sub>等の多結晶のセラミック強誘電体、LiNbO<sub>3</sub>やLiTaO<sub>3</sub>等の単結晶のセラミック強誘電体、或いはP(VDF)等の高分子強誘電体等が挙げられる。強誘電体の厚みは50nm~2000μm、好ましくは100nm~200μmがよい。50nm未満では強誘電体に形成している上部電極或いは電子放出および供給電極と下部電極が短絡してしまう問題が生じる。また、2000μmを越えると動作電界が非常に大きな値になり実用上問題が生じる。

【0007】 本発明における電子放出および供給電極の厚みは上部電極の厚さより薄くなければならないが、一般には5000Å以下であり、好ましくは1000Å以下、更に好ましくは400Å以下がよい。但し、使用する電極材によりその適正な値の範囲は変動する。例えばPtを使用した場合、好ましくは50~1000Å、更に好ましくは200~400Åがよい。5000Åを越える厚みではその厚さのため電子の放出が妨げられてしまう。

【0008】 本発明における電子放出および供給電極の面積は、上部電極および強誘電体の電子放出面全面を覆った時に最大になり、このときに電子の放出量も最大となるが、電子の放出量を制御するため、必要に応じて上部電極および強誘電体の電子放出面を覆う面積を制御してもよい。電極の設置方法は一般に用いられる方法のいずれでもよく、スパッタリング法や蒸着法等が挙げられる。

【0009】 本発明における電子放出および供給電極の材質としては、一般に電極材として用いられるものであればいずれのものでもよく、Pt, Au, Cu, Al, W, Ni, Cr, Co等の金属、或いは前記金属の合金等が挙げられる。また、電極の設置方法は一般に用いられる方法のいずれでもよく、スパッタリング法や蒸着法等が挙げられる。

【0010】 本発明における上部電極は、接地されており、効率よく接地させるためにはその厚さは2000Å以上であり、好ましくは400Å~5000Å、更に好ましくは1000Å~3000Åがよい。但し、使用する電極材によりその適正値の範囲は変動する。

【0011】 本発明における上部電極の形状は電子の放出に影響が生じない限り、線状、島状、螺旋状、格子状、ストライプ状等どのような形状を用いてもよい。

【0012】 本発明における上部電極の材質としては、一般に電極材として用いられるものであればいずれのものでもよく、Pt, Au, Cu, Al, W, Ni, Cr, Co等の金属、或いは前記金属の合金等が挙げられる。また、電極の設置方法は一般に用いられる方法のいずれでもよく、スパッタリング法や蒸着法等が挙げられる。

【0013】 本発明における上部電極の面積は、上部電

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極を覆って形成される電子放出および供給電極の効果を防げない面積にする必要があり、その面積は強誘電体の面積の0.05～95%、好ましくは0.5～50%、更に好ましくは5～10%がよい。上部電極の面積が強誘電体の面積の0.05%より小さいと接地が困難になり、また、95%を越えると十分な電子の放出が行えなくなる。

【0014】本発明で印加する動作電界は、正と負の両電界、或いは正または負のどちらか一方の電界のいずれでもよく、また、いずれの場合もその絶対値において0～100kV/cm、好ましくは20～40kV/cmがよい。100kV/cmを越える電界ではその高電界のため電極或いは強誘電体が破壊されてしまうという問題が生じる。

【0015】本発明における動作電界のパルス時間は、0.01μ秒～1000μ秒、好ましくは5μ秒～200μ秒がよい。0.01μ秒未満ではパルス時間が短いため、十分な電子の放出量が得られない。また、1000μ秒を越えた時間を印加しても1000μ秒以下の時間で放出する電子の放出量以上は得られない。

【0016】本発明における上部電極の材質は、一般に電極材として用いられるものであればいずれのものでもよく、Pt、Au、Cu、Al、W、Ni、Cr、Cs等の金属、或いは前記金属の合金等が挙げられる。電極の設置方法は一般に用いられる方法のいずれでもよく、スパッタリング法や蒸着法等が挙げられる。

【0017】

【作用】本発明の作用は、強誘電体の電子放出面側に形成してある上部電極および強誘電体の電子放出面を覆

い、且つその厚さが上部電極よりも薄い電子放出および供給電極を強誘電体に形成することにより、従来強誘電体の一部しか利用されていなかった放出面積を拡大すると共に、放出用電子の放出面全体への供給を容易にすることができ、大量且つ安定した電子の放出を行う点にある。

【0018】

【実施例】図1に本発明における強誘電体電子放出冷蔵庫の構成図を示す。1は電子放出および供給電極であり、上部電極および強誘電体全面にスパッタリング法や蒸着法により形成されている。2は上部電極であり、強誘電体にスパッタリング法や蒸着法等により形成されており、接地とされている。3は強誘電体である。4は下部電極であり、強誘電体全面にスパッタリング法や蒸着法等により形成されている。

【0019】本実施例では、強誘電体として厚さ60μmのPZTセラミックスを用いた。電極は全てPtを使用し、スパッタリング法にて設置した。下部電極は強誘電体全面に厚さ2000Åで設置した。上部電極はストライプ状に設置した。動作電界はパルスジェネレーターにより正と負一対の電界を印加したが、勿論正または負のどちらか一方の電界の印加でもよい。表1に電子放出測定の結果を示す。尚、放出電荷量は、放出電子が測定用電極に接続された負荷抵抗を通る際の電位差から求めた放出電流値の時間積分により算出した。また、放出の安定性は動作電界に追従した放出が認められたときを安定、やや不連続に放出が認められたときをやや不安定、放出が不連続のときを不安定とした。

【表1】

|                   | 比較例   | 比較例   | 本発明例 | 本発明例 | 本発明例 | 本発明例  | 比較例   |
|-------------------|-------|-------|------|------|------|-------|-------|
| 強誘電体              | PZT   | PZT   | PZT  | PZT  | PZT  | PZT   | PZT   |
| 電子放出および供給電極厚さ(μm) | 無し    | 無し    | 50   | 200  | 400  | 1000  | 6000  |
| 上部電極厚さ(μm)        | 無し    | 100   | 500  | 1000 | 2000 | 3000  | 500   |
| 動作電界(kV/cm)       | ±20   | ±25   | ±25  | ±25  | ±25  | ±25   | ±25   |
| 放出電荷量(μC)         | 0.046 | 0.050 | 0.92 | 1.51 | 2.80 | 0.65  | 0.000 |
| 放出の安定性            | 不安定   | 不安定   | 特不安定 | 安定   | 安定   | やや不安定 | 不安定   |

本実施例のように上部電極および強誘電体の電子放出面を覆い、且つ厚さが上部電極よりも薄い電子放出および供給電極を強誘電体に形成することにより、大量且つ安定した電子の放出が可能な強誘電体電子放出冷蔵庫を得ることができた。

【0020】

【発明の効果】本発明では、上部電極および強誘電体の電子放出面を覆い、且つ厚さが上部電極よりも薄い電子放出および供給電極を強誘電体に形成することにより、大量且つ安定した電子の放出が可能な強誘電体電子放出

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冷陰極を得ることができる。

【図面の簡単な説明】

【図1】本発明の実施例における強誘電体電子放出冷陰極の構成図。

【図2】従来の強誘電体電子放出冷陰極の構成図（Journal of Applied Physics p97569(2) (1991)）。

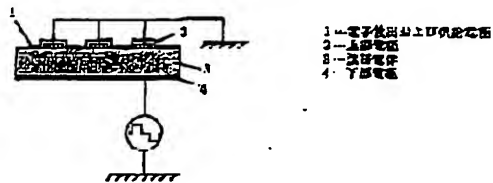
【図3】従来の強誘電体電子放出冷陰極の構成図（特開

平5-325777）。

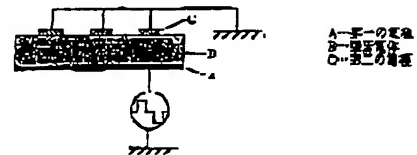
【符号の説明】

- 1 電子放出および供給電極
- 2 上部電極
- 3 強誘電体
- 4 下部電極

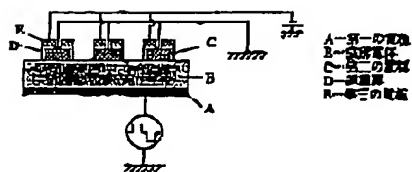
【図1】



【図2】



【図3】



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**CLAIMS**

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[Claim(s)]

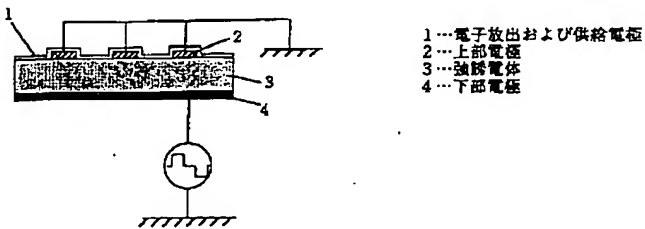
[Claim 1] Ferroelectric electron emission cold cathode characterized by covering the electron emission side of said up electrode and a ferroelectric, and thickness forming electron emission thinner than an up electrode and a supply electrode in a ferroelectric in the ferroelectric electron emission cold cathode which consists of a ferroelectric, an up electrode formed in the electron emission side side of the ferroelectric, and a lower electrode formed in the field opposite to the electron emission side side of the ferroelectric.

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[Translation done.]

Drawing selection

Representative drawing



[Translation done.]



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**DETAILED DESCRIPTION**

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[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the ferroelectric electron emission cold cathode used as an electron source.

[0002]

[Description of the Prior Art] Drawing 2 is the ferroelectric electron emission cold cathode using a ferroelectric, and is reported by H.Gundel etc. (Journal of Applied Physics p975 69(2), (1991)). A is [ a ferroelectric and C of the first electrode and B ] the second electrode. Moreover, drawing 2 is the ferroelectric electron emission cold cathode indicated by JP,5-325777,A, and, for the first electrode and B, a ferroelectric and C are [ A / an insulator layer and E of the second electrode and D ] the third electrode. In the conventional ferroelectric electron emission cold cathode constituted like drawing 1 and drawing 2 , if an alternating electric field is impressed between the first electrode and the second electrode, with change of the electric field, polarization inside a ferroelectric will flip off the electron which exists change (polarization reversal) near the second electrode in a lifting and that case according to Coulomb force, and will emit an electron.

[0003]

[Problem(s) to be Solved by the Invention] However, with the above configurations, there was a problem that an electronic burst size had them and it could not be used as a practical source of electron emission since [ for which only the electron which exists near the second electrode is used for emission ] in other words an electronic emission area will be limited. [ few ] Moreover, in order to make the amount of electron emission increase, although it had to be processed minutely and an electronic emission area had to be extended, there was a large number or a problem that the making process was very difficult, about the second electrode.

[0004] This invention was made in view of such the actual condition, and aims at offering practical ferroelectric electron emission cold cathode.

[0005]

[Means for Solving the Problem] The above-mentioned trouble is solved by the ferroelectric electron emission cold cathode characterized by covering the electron emission side of said up electrode and a ferroelectric, and thickness forming electron emission thinner than an up electrode and a supply electrode in a ferroelectric in the ferroelectric electron emission cold cathode which consists of an up electrode formed in the electron emission side side of a ferroelectric and its ferroelectric, and a lower electrode formed in the field opposite to the electron emission side side of the ferroelectric.

[0006] the ferroelectric in this invention -- PZT [Pb(Zr, Ti) O<sub>3</sub>], PLZT [(Pb, La) (Zr, Ti) O<sub>3</sub>], and BaTiO<sub>3</sub> etc. -- the ceramic ferroelectric of polycrystal, and LiNbO<sub>3</sub> LiTaO<sub>3</sub> etc. -- macromolecule ferroelectrics, such as a ceramic ferroelectric of a single crystal or PVDF, etc. are mentioned. The thickness of a ferroelectric has 50nm - 2000 micrometers 100nm - preferably good 200 micrometers. In less than 50nm, the problem which the up electrode or the electron emission and the supply electrode which are formed in a ferroelectric, and a lower electrode short-circuit arises. Moreover, if 2000 micrometers is exceeded, electric field of operation will become a very big value, and a problem will arise practically.

[0007] Although the thickness of the electron emission in this invention and a supply electrode must be thinner than the thickness of an up electrode, generally it is 5000A or less, and 400A or less 1000A or less is still more preferably good preferably. However, the range of the proper value is changed by the electrode material to be used. For example, when Pt is used, 50-1000A 200-400A is still more preferably good preferably. By the thickness exceeding 5000A, electronic emission will be barred for the thickness.

[0008] When the whole electron emission side surface of an up electrode and a ferroelectric is covered, it becomes max and an electronic burst size also serves as max at this time, but the area of the electron emission in this invention and a supply electrode may control wrap area for the electron emission side of an up electrode and a ferroelectric if needed in order to control an electronic burst size. Any of the approach generally used are sufficient as the installation approach of an electrode, and the sputtering method, vacuum deposition, etc. are mentioned.

[0009] As the quality of the material of the electron emission in this invention, and a supply electrode, if generally used as electrode material, which thing may be used and the alloy of metals, such as Pt, Au, Cu, aluminum, W, nickel, Cr, and Cs, or said metal etc. will be mentioned. Moreover, any of the approach generally used are sufficient as the installation approach of an electrode, and the sputtering method, vacuum deposition, etc. are mentioned.

[0010] In order to ground the up electrode in this invention and to ground it efficiently, the thickness is 200A or more, and 400A - 5000A 1000A - its 3000A is still more preferably good preferably. However, the range of the proper value is changed by the electrode material to be used.

[0011] The configuration of the up electrode in this invention may use what kind of configurations, such as the shape of the shape of the shape of a line and an island, a swirl, and a grid, and a stripe, unless effect arises in electronic emission.

[0012] As the quality of the material of the up electrode in this invention, if generally used as electrode material, which thing may be used and the alloy of metals, such as Pt, Au, Cu, aluminum, W, nickel, Cr, and Cs, or said metal etc. will be mentioned. Moreover, any of the approach generally used are sufficient as the installation approach of an electrode, and the sputtering method, vacuum deposition, etc. are mentioned.

[0013] the area which does not bar the effectiveness of the electron emission which the area of the up electrode in this invention covers an up electrode, and is formed, and a supply electrode -- it is necessary to carry out -- the area -- the area of a ferroelectric -- it is still more preferably [ 5 - 10% of ] good 0.5 to 50% preferably 0.05 to 95%. If the area of an up electrode is smaller than 0.05% of the area of a ferroelectric, touch-down will become difficult, and when 95% is exceeded, it becomes impossible to emit enough electrons.

[0014] Any of forward, both negative electric fields, or electric field forward or negative [ either ] are sufficient as the electric field of operation impressed by this invention, and, in any case, they are preferably good zero to 100 kv/cm in the absolute value. [ of 20 - 40 kv/cm ] In the electric field exceeding 100 kv/cm, the problem that an electrode or a ferroelectric will be destroyed for [ the ] high electric field arises.

[0015] The pulse period of the electric field of operation in this invention has 5 microseconds - 200 preferably good microseconds for 0.01 microseconds to 1000 microseconds. In less than 0.01 microseconds, since the pulse period is short, the burst size of enough electrons is not obtained. Moreover, even if it impresses the time amount exceeding 1000 microseconds, more than the burst size of the electron emitted by the time amount for 1000 or less microseconds is not obtained.

[0016] As long as the quality of the material of the lower electrode in this invention is generally used as electrode material, which thing is sufficient as it, and the alloy of metals, such as Pt, Au, Cu, aluminum, W, nickel, Cr, and Cs, or said metal etc. is mentioned. Any of the approach generally used are sufficient as the installation approach of an electrode, and the sputtering method, vacuum deposition, etc. are mentioned.

[0017]  
[Function] An operation of this invention can make easy supply to the whole emission side of the electron for emission, and is in extensive and the point which emit the stable electron while it expands the emission area for which some ferroelectrics were conventionally used by covering the electron-emission side of the up electrode currently formed in the electron-emission side side of a ferroelectric, and a ferroelectric, and forming electron emission with the thickness thinner than an up electrode, and a supply electrode in a ferroelectric.

[0018]  
[Example] The block diagram of the ferroelectric electron emission cold cathode in this invention is shown in drawing 1. 1 is electron emission and a supply electrode, and is formed by the sputtering method or vacuum deposition all over the up electrode and the ferroelectric. 2 is an up electrode, is formed in the ferroelectric by the sputtering method, vacuum deposition, etc., and is grounded. 3 is a ferroelectric. 4 is a lower electrode and is formed by the sputtering method, vacuum deposition, etc. all over the ferroelectric.

[0019] In this example, PZT ceramics with a thickness of 60 micrometers was used as a ferroelectric. All electrodes used Pt and installed it by the sputtering method. The lower electrode was installed by 2000A in thickness all over the ferroelectric. The up electrode was installed in the shape of a stripe. Although electric field of operation impressed forward and the electric field of a negative pair with the pulse generator, impression of one of electric fields forward [ natural ] or negative is sufficient as it. The result of electron emission measurement is shown in Table 1. In addition,

the amount of emission charges was computed according to the time quadrature of the emission current value calculated from the potential difference at the time of the emission electron passing along the load resistance connected to the electrode for measurement. Moreover, the stability of emission made unstable the time of instability and emission being discontinuity a little about stability and the time of emission being accepted a little in discontinuity in the time of the emission which followed in footsteps of of operation electric field being accepted.

[Table 1]

|                   | 比較例    | 比較例    | 本発明例   | 本発明例    | 本発明例    | 本発明例    | 比較例     |
|-------------------|--------|--------|--------|---------|---------|---------|---------|
| 強誘電体              | P Z T  | P Z T  | P Z T  | P Z T   | P Z T   | P Z T   | P Z T   |
| 電子放出および供給電極厚さ (Å) | 無し     | 無し     | 5 0    | 2 0 0   | 4 0 0   | 1 0 0 0 | 6 0 0 0 |
| 上部電極 (Å)          | 無し     | 1 0 0  | 5 0 0  | 1 0 0 0 | 2 0 0 0 | 3 0 0 0 | 5 0 0   |
| 動作電界 (kV/cm)      | ± 2 5  | ± 2 5  | ± 2 5  | ± 2 5   | ± 2 5   | ± 2 5   | ± 2 5   |
| 放出電荷量 (μ C)       | 0. 045 | 0. 056 | 0. 7 2 | 1. 5 1  | 2. 5 0  | 0. 6 5  | 0. 050  |
| 放出の安定性            | 不安定    | 不安定    | 不安定    | 安定      | 安定      | 不安定     | 不安定     |

A lot of [ and ] ferroelectric electron emission cold cathode which can emit the stable electron was able to be obtained by covering the electron emission side of an up electrode and a ferroelectric like this example, and forming electron emission with thickness thinner than an up electrode, and a supply electrode in a ferroelectric.

[0020]

[Effect of the Invention] In this invention, a lot of [ and ] ferroelectric electron emission cold cathode which can emit the stable electron can be obtained by covering the electron emission side of an up electrode and a ferroelectric, and forming electron emission with thickness thinner than an up electrode, and a supply electrode in a ferroelectric.

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] The block diagram of the ferroelectric electron emission cold cathode in the example of this invention.

[Drawing 2] The block diagram of the conventional ferroelectric electron emission cold cathode (Journal of Applied Physics p97569 (2) (1991)).

[Drawing 3] The block diagram of the conventional ferroelectric electron emission cold cathode (JP,5-325777,A).

[Description of Notations]

1 Electron Emission and Supply Electrode

2 Up Electrode

3 Ferroelectric

4 Lower Electrode

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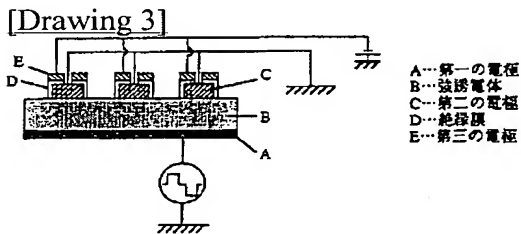
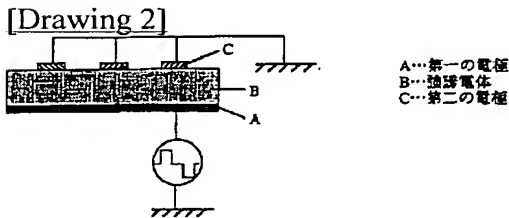
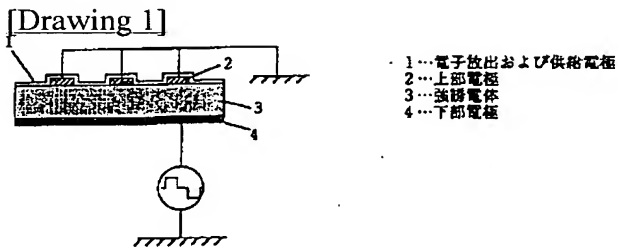
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DRAWINGS



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